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## TEMPERATURE AS A FACTOR IN THE CONTROL OF THE WESTERN PINE BEETLE

In the effort to find better, cheaper and more effective methods controlling bark beetle infestations, we cannot afford to overlook any natural agencies that contribute to the mortality of these insects. Some years ago the use of solar heat was developed in the control of the western pine beetle. This method of control was based on experiments which brought out the fact that the amount of heat absorbed by infested bark exposed to direct sunlight was sufficient to kill the broods. Complete mortality is assured if bark temperatures reach a maximum of 115 to 118 degrees Fahr. for a period of two hours or more. Under clear summer weather conditions, with air temperatures ranging from 80 to 95 degrees, bark removed from the log and placed on the ground with the inner surface toward the sun will reach maximum temperatures from 110 to 130 degrees F. This method, however, is effective only during the summer season and can be used merely to supplement the general practice of burning the infested bark during the fall, winter and spring periods.

Although freezing cannot be used in artificial control methods, it is recognized that low temperatures may result in appreciable killing of western pine beetle broods under field conditions. In 1924 a severe cold spell preceded initiation of control work on the Metolius Project near Bend, Oreg. Mr. A.J. Jaenicke, who started the spotting work on this area, soon found that a high percentage of broods in the outer bark were dead, and that burning the bark would only involve an unnecessary expense. In view of this condition control work was abandoned and the infestation subsided to an endemic condition the following season. The high mortality of the broods could be explained only by the low temperatures, which reached minima of 20 to 25 degrees below zero in the vicinity of Bend.

Since 1926 the Bureau of Entomology has been carrying on a series of laboratory experiments which have effectively shown the susceptibility of western pine beetle broods to low temperatures, such as may at times occur in infested bark in the field. By means of special freezing apparatus infested bark was lowered through a range of temperatures ranging from 60 above to 20 below zero F.

It was found that larvae overwintering in the lower yellow pine areas of the Sierra Nevada region died as a result of freezing when bark temperatures were lowered below zero F. Partial mortality occurred at zero; the mortality at -5 degrees exceeded 60 per cent, and no larvae survived -10 degrees. Complete mortality developed within this range of temperatures regardless of whether the larvae were actively developing or dormant at the time of exposure to the critical points.

Pupae were found to be slightly less resistant to cold, high mortality occurring between 5 above and 5 below zero, and mortality was complete at 8 degrees below zero F.

The adults were the least resistant of all brood stages; high mortality developed between 12 and 5 degrees above, and mortality was complete at zero. Partial mortality of eggs in the cambium developed between 5 above and 10 below zero; however, about 10 per cent of the eggs survived a temperature of 15 below, indicating greater resistance to cold than the other brood stages.

In regions where the minimum winter temperatures fall considerably below zero the broods apparently develop greater resistance to cold than in regions of mild winter climate. Larvae which had passed through the over-wintering period at Coeur d'Alene, Id., where air temperatures of 10 below had been recorded, developed high mortality when the bark temperatures were lowered in a freezing cabinet through the range from 5 above to 10 below. About 25 per cent of the brood survived this point, but mortality was complete at 18 degrees below zero. These broods were apparently able to withstand about 10 more degrees of cold than those from the Sierra Nevada region.

It is obvious that western pine beetle broods do survive cold spells where weather records indicate minimum air temperatures considerably below those which would be fatal to broods in the bark. This is due to the fact that the outer bark on standing infested trees cools down more slowly than the surrounding air and does not reach the minimum temperatures recorded by weather thermometers. Records secured by J.C. Evenden and H.J. Rust at Coeur d'Alene, Id., during two short periods of subzero weather, indicate that the minimum bark temperatures are 10 to 12 degrees higher than minimum air temperatures. This dispersion between bark and air temperatures probably accounts for the fact that western pine beetle infestation occurs in yellow pine areas with severe winter climate. However, the heaviest epidemics seem to have developed in regions where long periods of subzero weather rarely occur.

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